Status of Reference Event Collection

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DTRA Program Review

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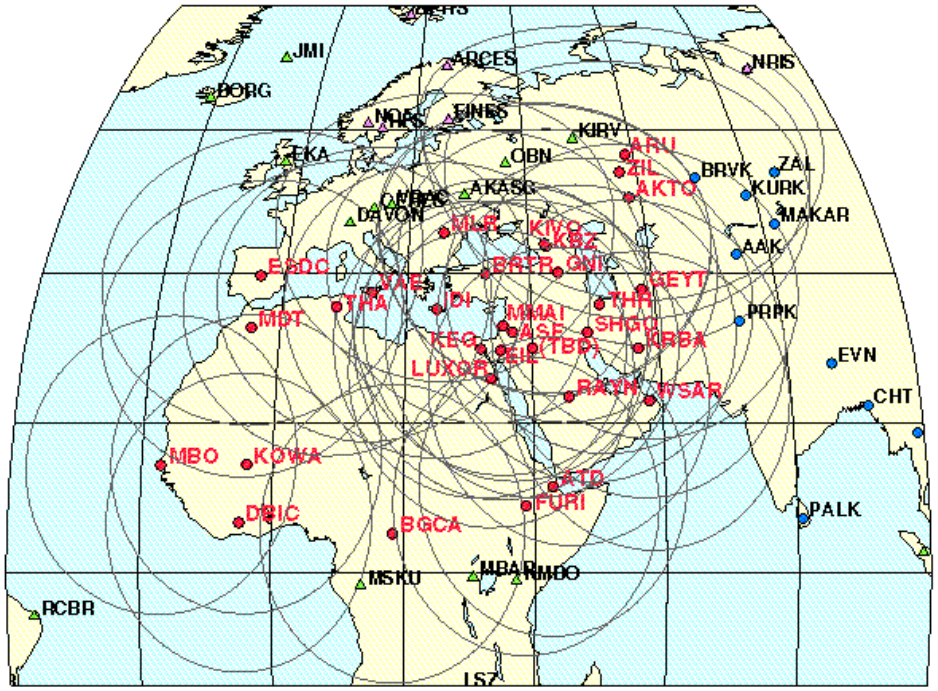
Overview

- Objectives
- Consortium effort to collect reference events
- Methodology
- Reference Event List 2.0
- Event clusters
- Summary

Objectives

- Compile a list of GT0-10 reference events in the Consortium's region of interest with emphasis on GT0-5 events
- Validate, document and QC each event
- Reference events are employed to validate
  - models
  - corrections and errors.



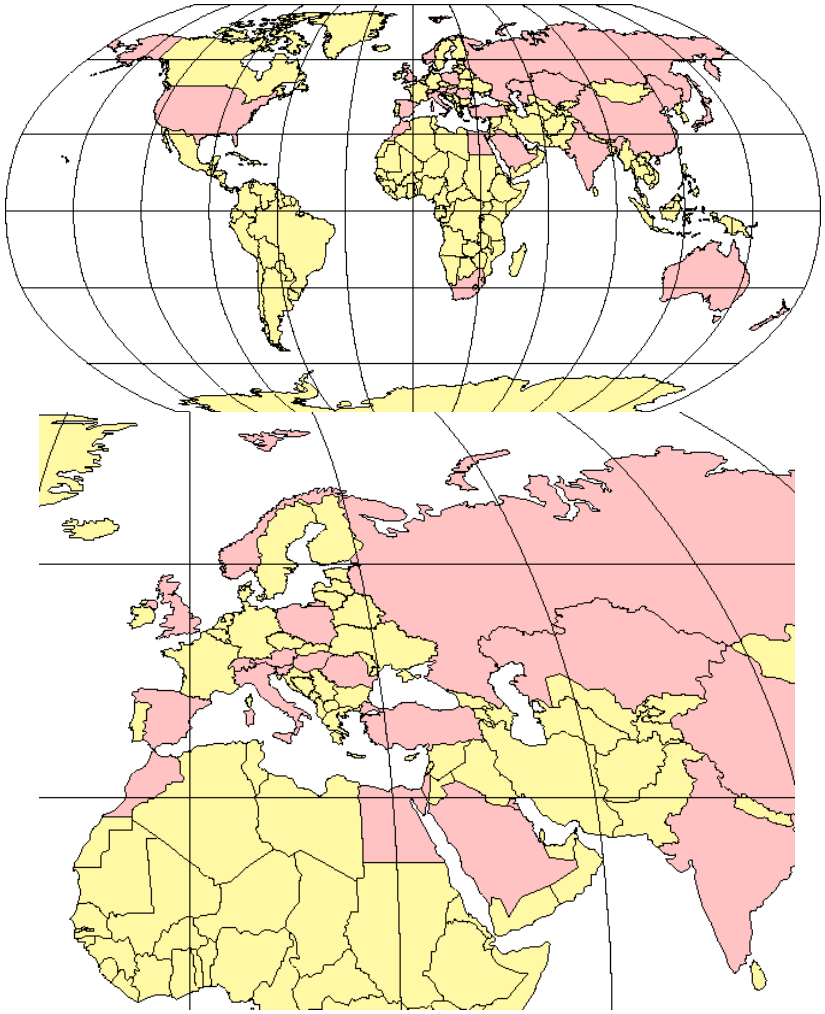
Consortium effort

- Nearly half of the Consortium work (and budget) is devoted to reference event collection and validation with the recognition that models and SSSCs cannot be validated without a suitable set of ground truth events
- Contacts have been established in the region (Multimax, GII, CUB, SAIC, WSC)
- Local bulletins that may not be publicly available have been acquired (Multimax, WSC, CUB, SAIC, Harvard)
- Phases are being picked from waveforms from non-reporting future IMS stations (GII, Multimax)
- Validation and documentation of reference events is an ongoing effort (CUB, SAIC)

Major contributions

http://g2calibration.cmr.gov/calibration/acknowledgement.html
http://g2calibration.cmr.gov/calibration/refref.html

- DOE LLNL delivery
- Local bulletins from Spain, Morocco, Kuwait, Saudi Arabia, Northern Caucasus, Turkey, Greece, Cyprus, Austria, Hungary, Romania, Egypt
- Shot locations of EGT, EuroBridge, Celebration2000, Vrancea99 and Saudi refraction profiles
- NNCKR list of Balapan nuclear explosions, PNE readings collected at Harvard, refined locations of Lop Nor explosions
- Reference events for clusters from Iran, China, India, Turkey, Egypt; potential clusters from Kuwait, Ghana, Djibouti
- Mid-ocean ridge and transform fault events
- ISC, NEIC, EMSC, REB, EHB searches
- CMR databases (Explo, REDB, Gamma, GT)



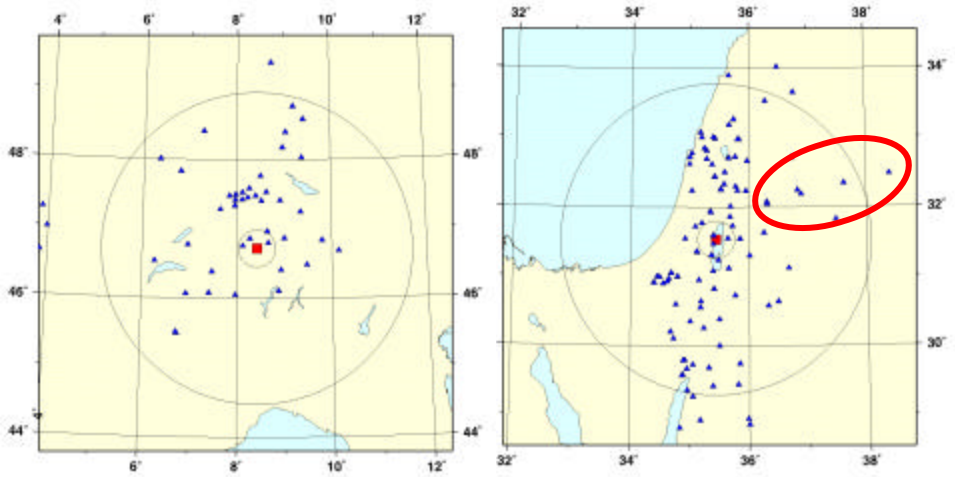
Methodology

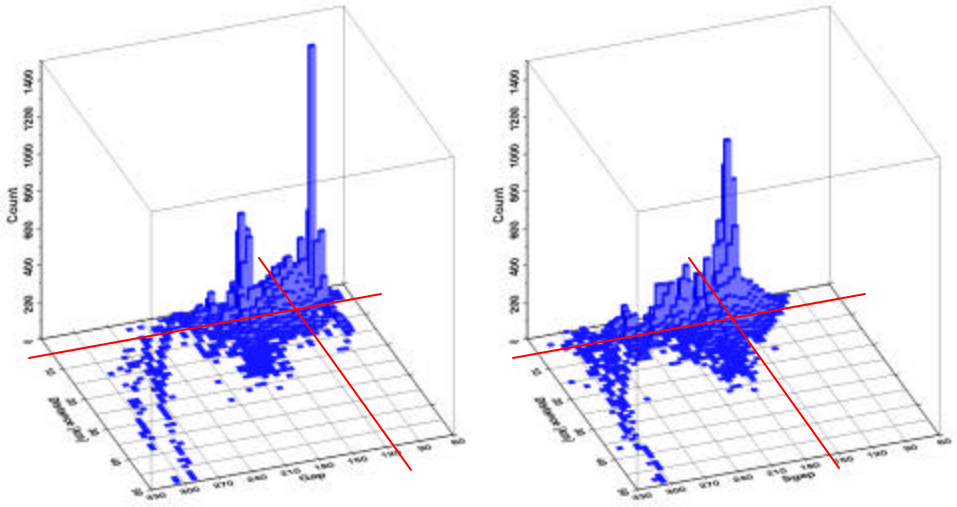
- Identify candidate reference events
  - Bulletin search using GT5 selection criteria
  - Use other independent information (e.g. bathymetry, space imagery, published papers, mine location, personal communications, etc.)
- Collect and merge arrivals from various sources
  - GT selection criteria may not be met without merging bulletins
- Validate candidate reference events
  - Cluster analysis (HDC, JHD)
  - Relocation using only local stations
- QC and vet arrivals
  - Conflicting station codes
  - Possible phase misassociations

GT5 selection criteria (Bondár et al.)

Relocation of two GT0 events with 10 randomly selected stations within 250km; 10,000 realizations

- No universal selection criteria exists
- Criteria that minimize the number of outliers and maximize the number of events with 5 km location accuracy at the 90% and 95% confidence level





Secondary azimuthal gap

- The largest azimuthal gap filled by a single station
- Tends to equalize relative station importances

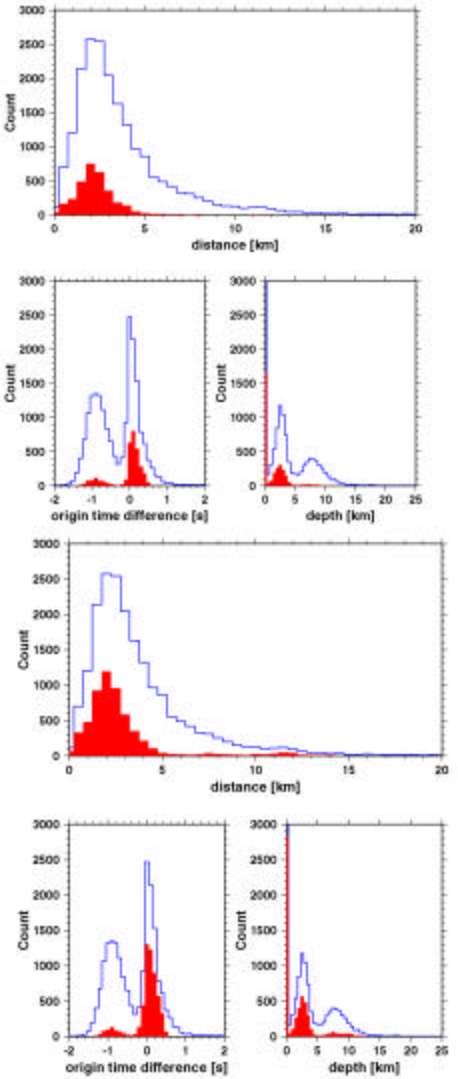
GT5 selection criteria

At the 95% confidence level

- At least 10 stations within 250 km with azimuthal gap<=110 degrees and with secondary azimuthal gap<=160 degrees
- At least one station within 30 km from the epicenter
- Event is recorded beyond 250 km

At the 90% confidence level

- At least 10 stations within 250 km with azimuthal gap<=110 degrees
- At least one station within 30 km from the epicenter
- Event is recorded beyond 250 km

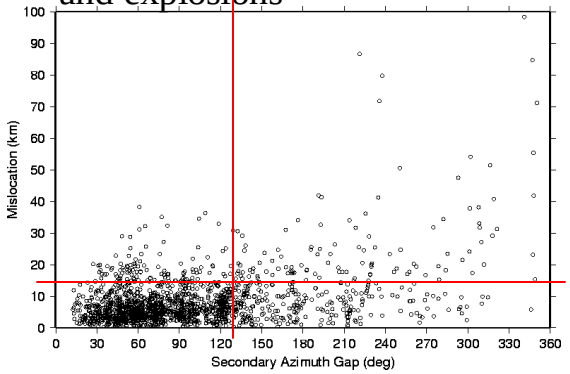


GT15 selection criteria (Engdahl et al.)

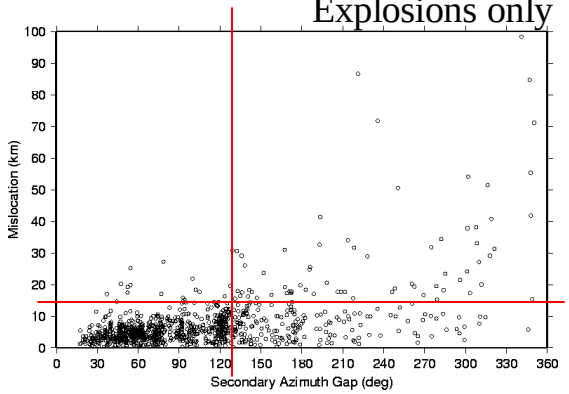
Relocation of 1,800 GT0-5 earthquakes and explosions using stations at all distances and later phases. Preliminary results.

Mislocation vs sgap

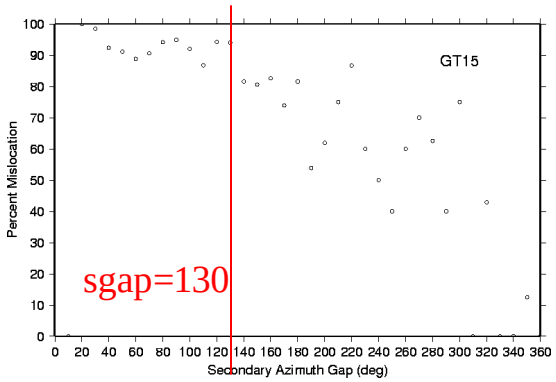
Earthquakes and explosions

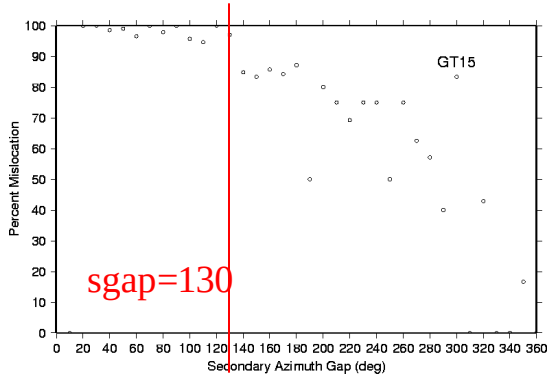


Explosions only



Percent of mislocation of 15 km or less





Validation of reference events

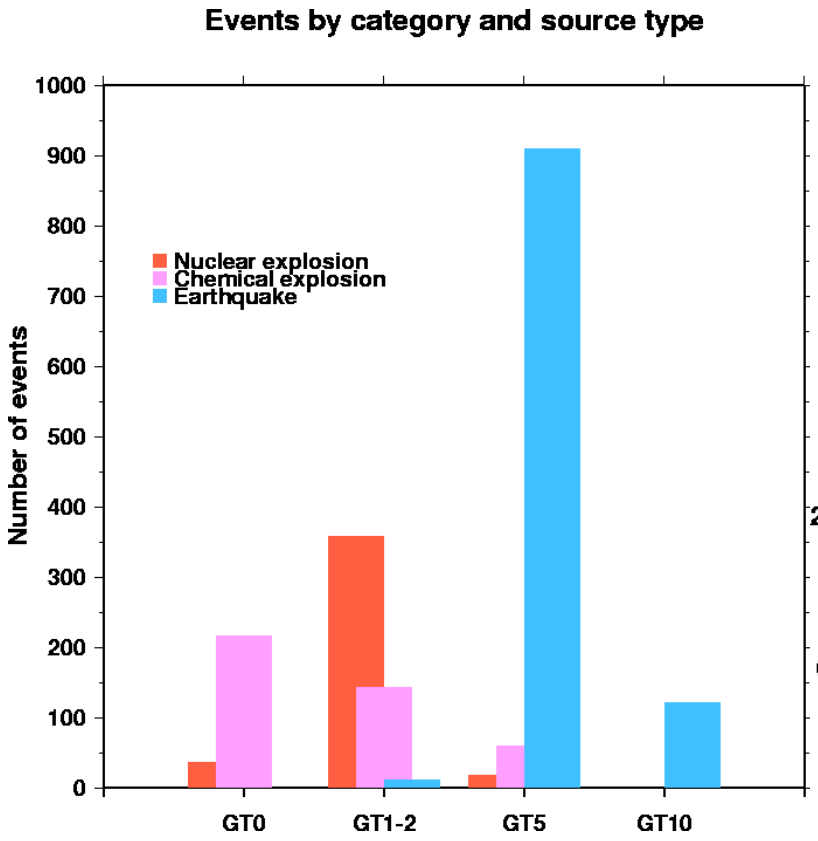
- Each reference event is documented with metadata
- Cluster analysis (CUB, SAIC)
  - candidate events are validated if multiple event location results are consistent with reference event information
  - Events from cluster are promoted to GT5 if the major axis of their error ellipse is less than 5.5 km
  - HDC and JHD techniques were cross-validated to ensure they give similar results
- Relocation using stations within 300 km if clusters cannot be formed (Multimax)
- Oracle database is sponsored by CMR

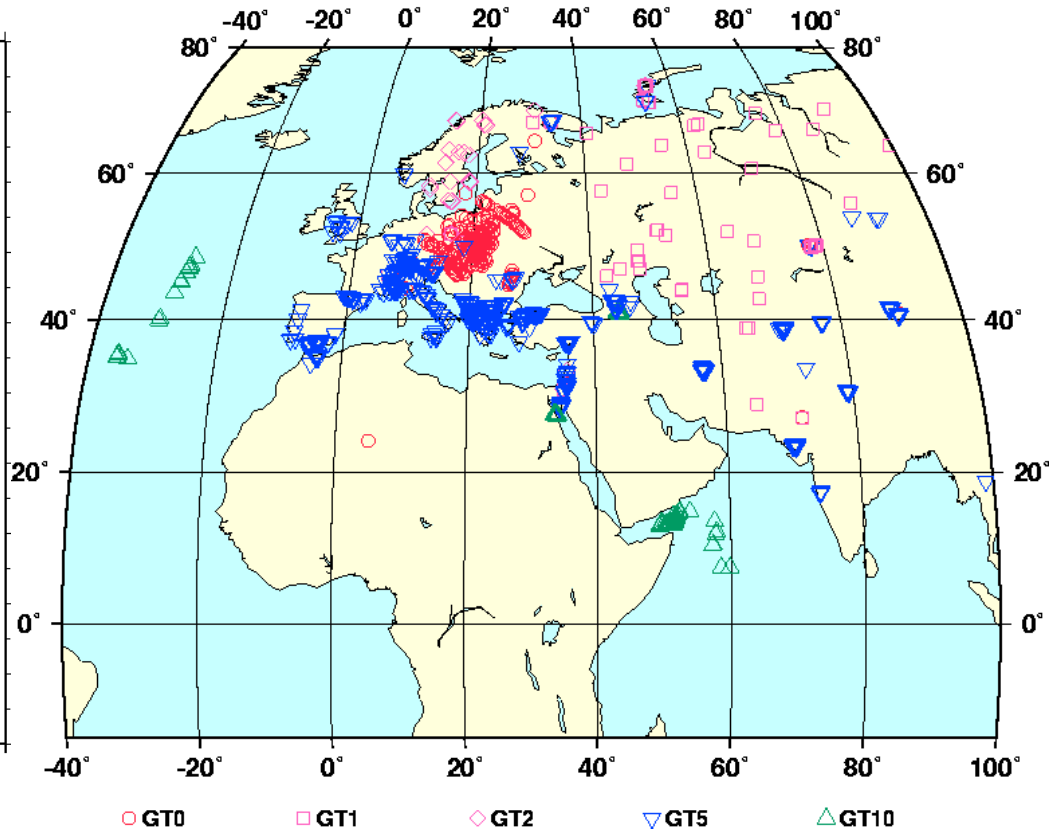
Sources of arrival data

- Global bulletins: ISC, EHB, PDE, REB, REDB
- Local bulletins collected by
  - Multimax (Kuwait, Morocco, Saudi Arabia, Spain),
  - GII (Turkey, Jordan, Cyprus, Greece)
  - WSC in cooperation with GSRAS (Azerbaijan, Dagestan, Georgia)
  - SAIC (Austria, Hungary, Romania, Slovenia)
- Arrivals picked from stations at future IMS sites if they are not reported to ISC (GII, Multimax)
- Arrivals are merged and vetted
  - Conflicting station codes are corrected
  - Duplicate arrivals are deleted
  - Possible phase misassociations (Pg/Pn/P, Sg/Sn/S) are investigated

Reference Event List 2.0 March, 2002

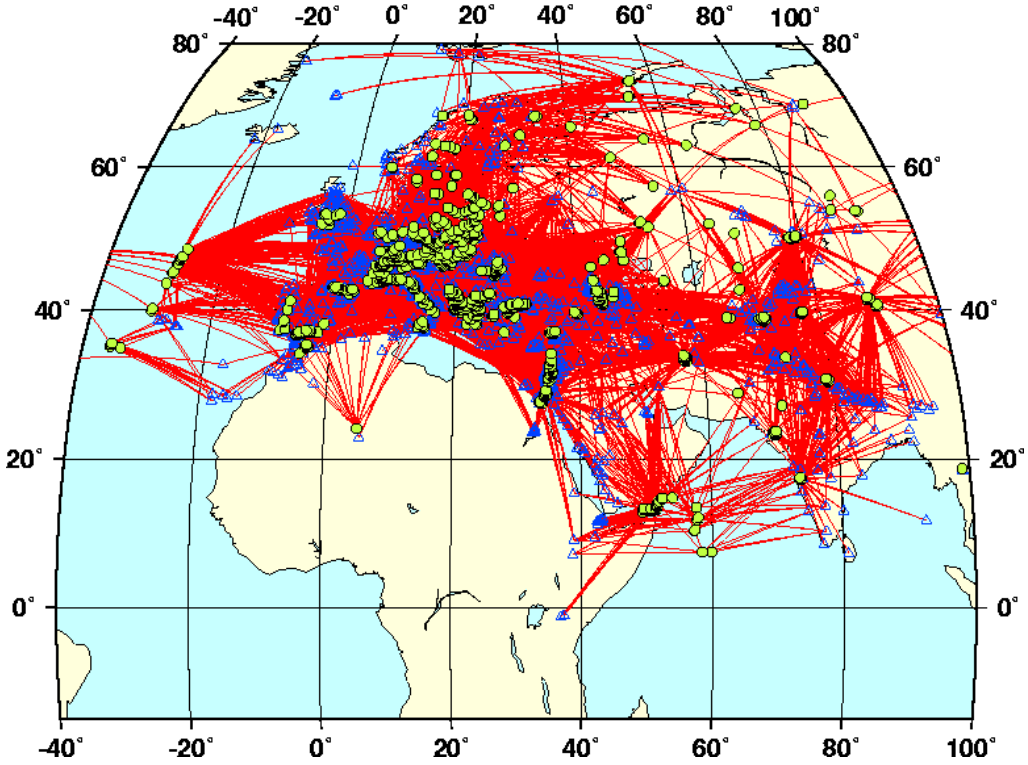
1870 GT0-10 events (REL1.0: 837 events)

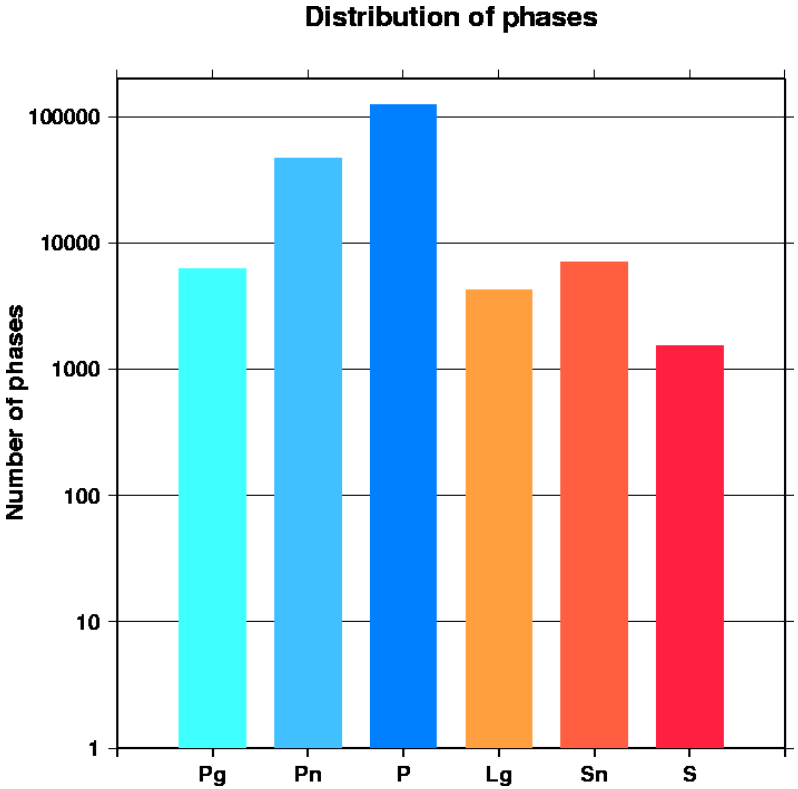




Reference Event List 2.0 March, 2002

64,258 regional rays (Pg, Pn, Sn, Lg)
126,360 teleseismic (P, S) rays
Limited coverage in Africa

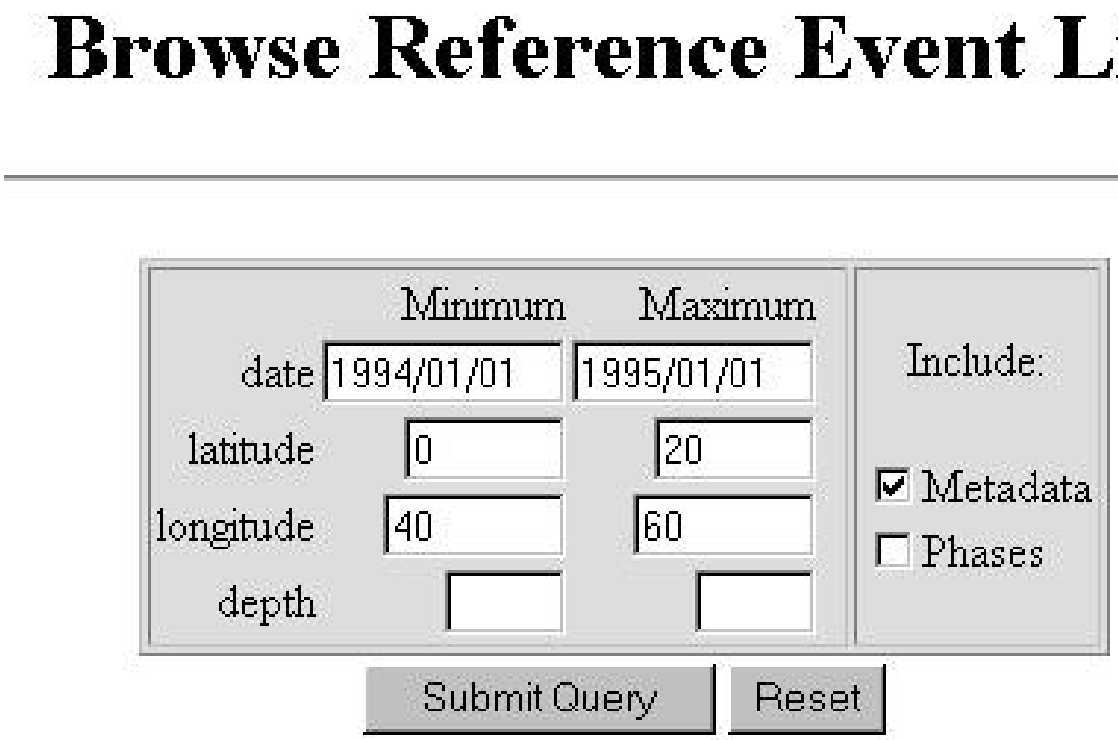




Reference Event List 2.0

- The Reference Event List is publicly available
- Submitted to the IASPEI Working Group on Reference Events

http://g2calibration.cmr.gov/calibration/data.html
http://g2calibration.cmr.gov/calibration/refsel.html



Reference Event List 2.0

Search results

For events between 1994/01/01 and 1995/01/01 in the coordinate rectangle (0.000, 40.000) - (20.000, 60.000)

Mid-Indian ridge	GT-level: 10	Author: PAN
Pan, J., M. Antolik and A. Dziewonski, Locations of mid-oceanic earthquakes constrained by sea-floor bathymetry, EOS Trans. AGU, 81, F868, 2000.		

```
DATA_TYPE ORIGIN IMS1.0
 Reference Event List of the Group2 Consortium,  generated 2002/03/14 21:01:37
   Date       Time        Err   RMS Latitude Longitude  Smaj  Smin  Az Depth   Err Ndef Nsta Gap  mdist  Mdist Qual   Author      OrigID
1994/03/19 10:43:32.10          4.15   7.4400   58.4300                 10.0        132  104 103  17.31 127.50 m i uk GROUP2    20818564

Magnitude  Err Nsta Author      OrigID

 (GT10- 10 km accuracy)
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Gulf of Aden cluster	GT-level: 10	Author: ENGDAHL_HDC
Engdahl, E.R. and E.A. Bergman, Validation and generation of reference events by cluster analysis, 23rd Seismic Research Review, Vol I, 205-214, October 2-5, 2001.		

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DATA_TYPE ORIGIN IMS1.0
 Reference Event List of the Group2 Consortium,  generated 2002/03/14 21:01:39
   Date       Time        Err   RMS Latitude Longitude  Smaj  Smin  Az Depth   Err Ndef Nsta Gap  mdist  Mdist Qual   Author      OrigID
1994/10/01 14:04:22.16   0.15  1.23  13.1500   50.3350   2.1   6.4 280  10.0f  0.0  145  145 110   9.09  91.86 m i uk GROUP2    21450306

Magnitude  Err Nsta Author      OrigID
mb      5.0          GROUP2    21450306
Ms      4.4          GROUP2    21450306

 (GT10- 10 km accuracy)
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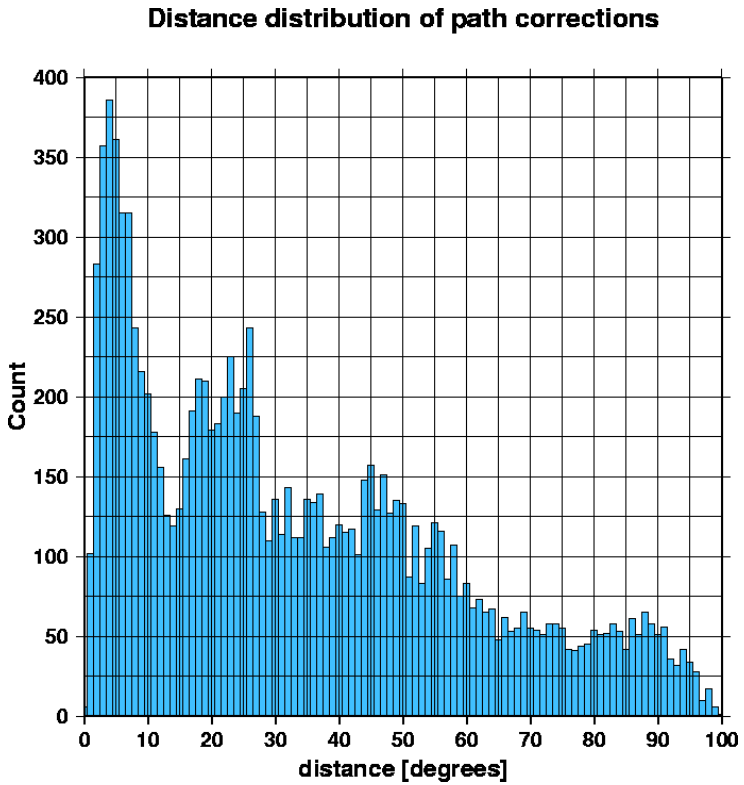
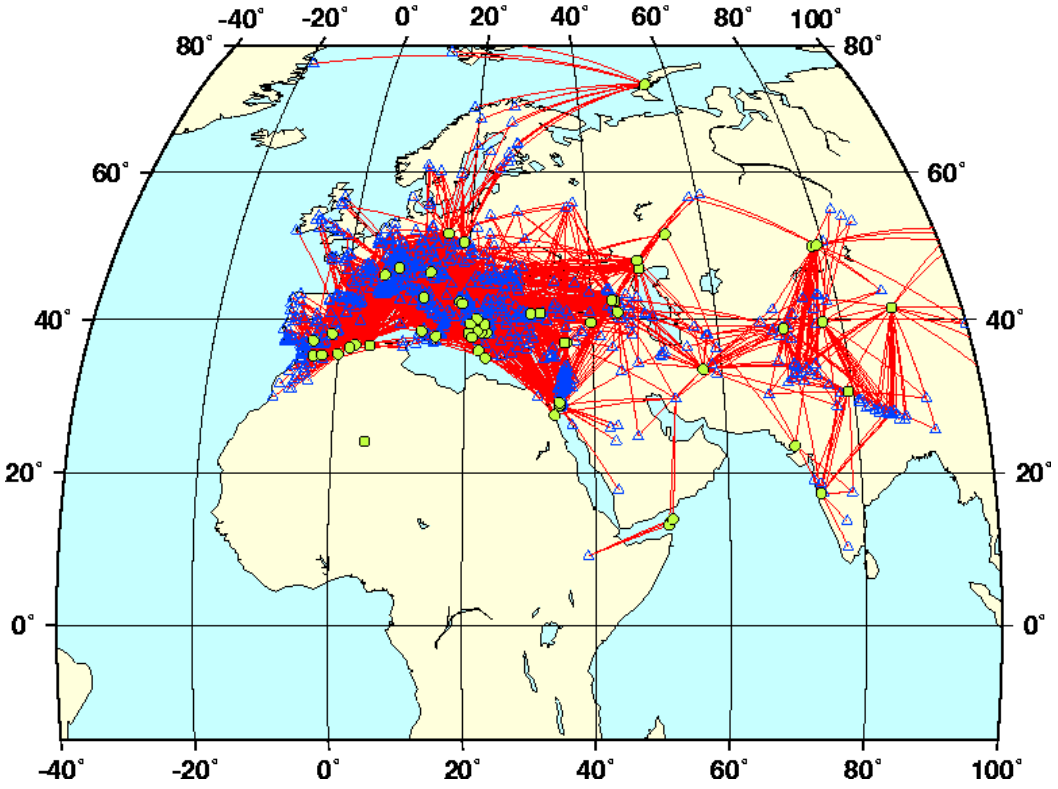
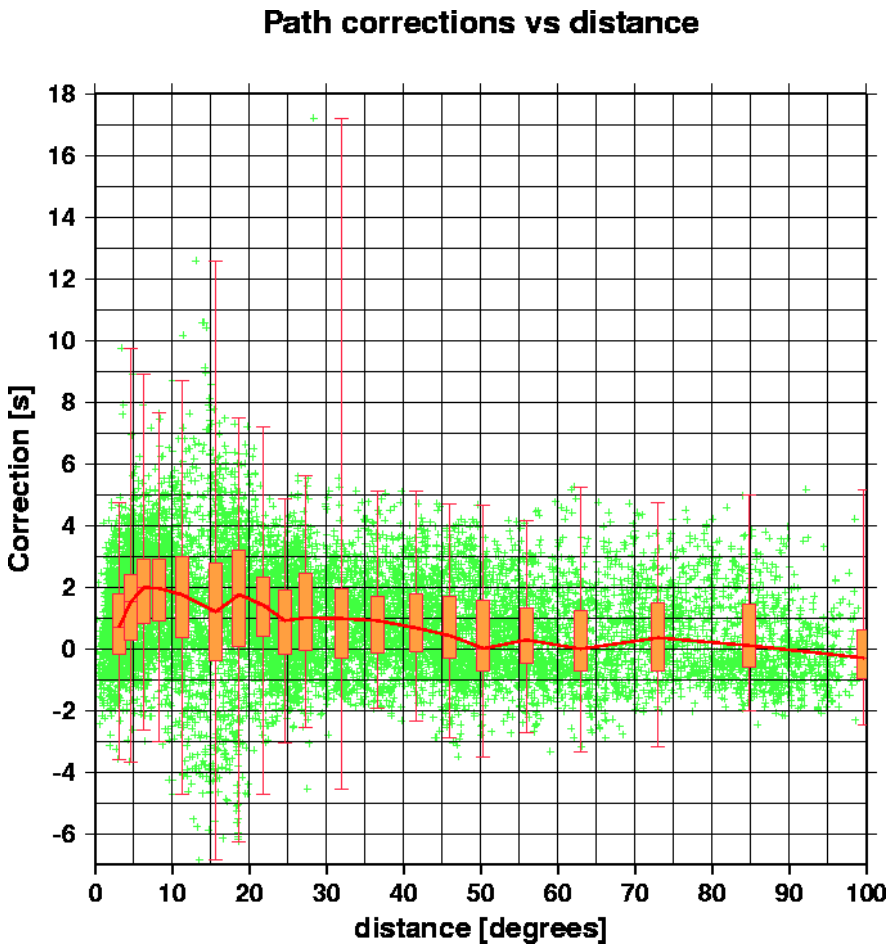
Event cluster database

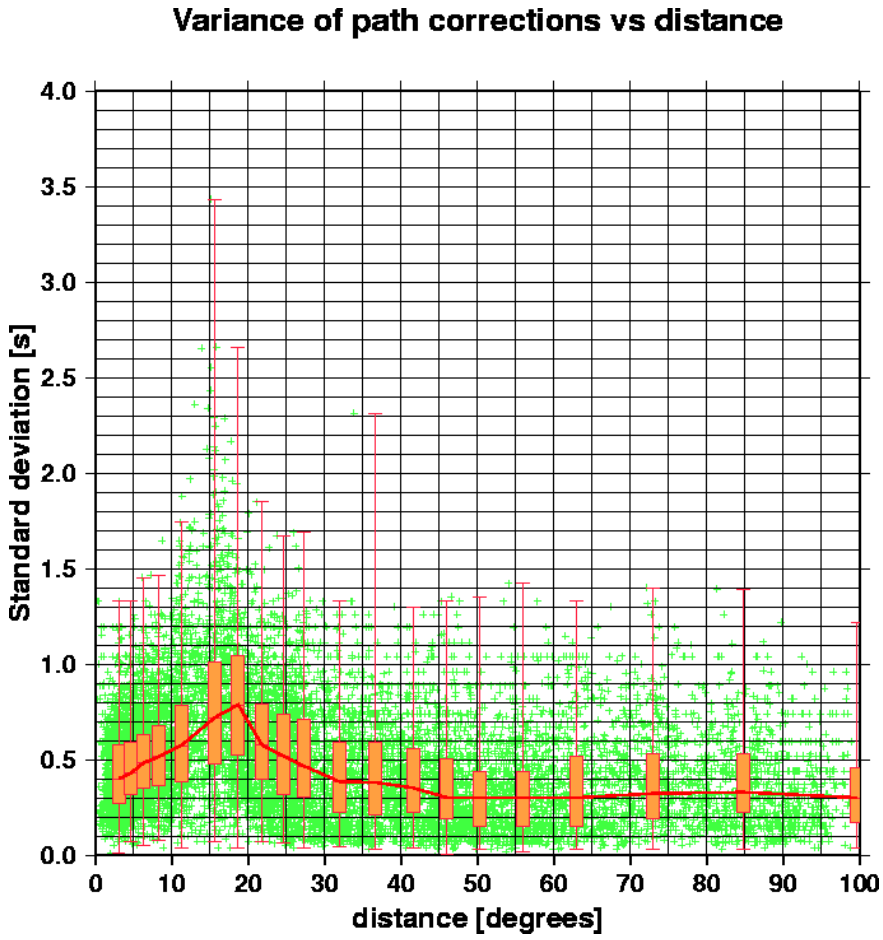
- Empirical path corrections produced by cluster analysis are used to validate SSSCs and model errors
- 62 event clusters, 4,004 regional and 7,691 teleseismic rays





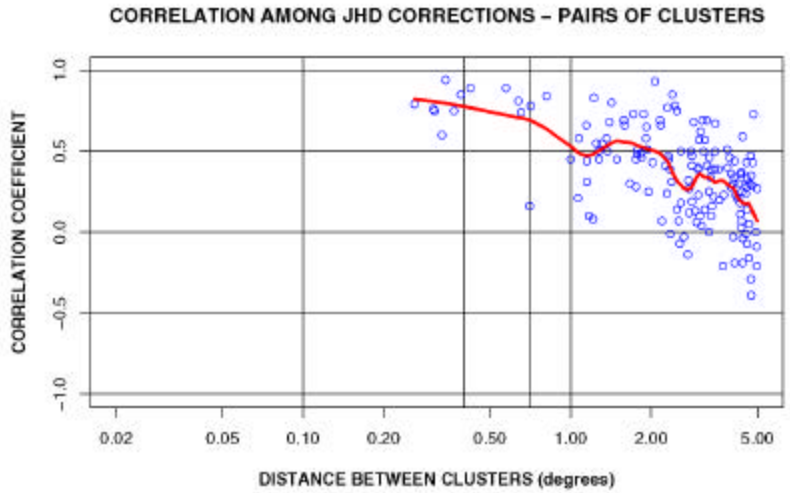
Event cluster database

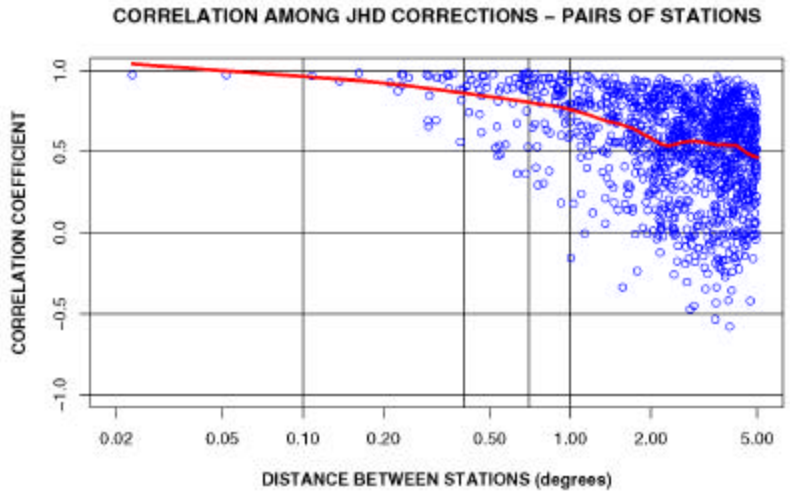




Event cluster database

- Pairs of clusters: correlation of path corrections between close clusters at a station; might be biased by origin time errors
- Pairs of stations: correlation of path corrections between stations at a cluster
- Empirical path corrections provide estimate for typical correlation length: ~100 km





Summary

- Reference event collection, validation and documentation is a major Consortium effort
- Reference event collection requires extensive international cooperation
- Reference event selection criteria are established
- More than 1,800 GT0-10 events in current Reference Event List
- Reference Event List releases are publicly available at http://g2calibration.cmr.gov
- Event cluster database with empirical path corrections is created